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Biological response of chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), to various regimes of chemical and biorational insecticides☆

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ABSTRACT

The chilli thrips *Scirtothrips dorsalis* (Hood) (Thysanoptera: Thripidae), a new invasive pest in the USA, is an economically important pest of certain vegetable, ornamental and fruit crops in southern and eastern Asia, Oceania and parts of Africa. These crops cannot be protected from the pest without resorting to the use of chemical insecticides. In order to forestall or delay the development of insecticide resistance in *S. dorsalis*, we continued our focus on the discovery of insecticides with different modes of action for rotational use. In this study we evaluated candidate insecticides to control *S. dorsalis* on 'Jalapeno' pepper, *Capsicum annuum* L.; these materials belong to different IRAC mode of action classes as follows: (i) 4A – neonicotinoids, i.e., imidacloprid, thiamethoxam and dinotefuran, (ii) 5 – spinosyns, i.e., spinosad and spinetoram, (iii) 3A – pyrethroids, i.e., β-cyfluthrin, esfenvalerate, ζ-cypermethrin and λ-cyhalothrin and (iv) 8D – borax mixed together with orange oil and detergents in the TriCon® formulation. In addition we evaluated the entomopathogenic fungus, *Beauveria bassiana* (Botanigard®) alone and in combination with the borax formulation at ½ of their usual rates of application. Each of the 3 neonicotinoid insecticides when applied either as a single foliar spray or as a soil drench significantly suppressed both adults and larvae for at least 10 days; indeed imidacloprid did so for 15 days. Dinotefuran was more effective as a foliar spray than as a soil drench. Spinosyns applied as a single foliar spray, significantly suppressed both adults and larvae through 15 days after treatment (DAT). None of the 4 pyrethroids provided significant suppression of either adults or larvae. The borax formulation suppressed adults and larvae through 10 DAT. *B. bassiana* significantly suppressed only the larvae at 5 DAT and not at 10 DAT. This study brings the number of insecticides known to be effective against *S. dorsalis* to 10 and these belong to 7 different modes of action classes. The use of such insecticides in rotation belonging to different classes will help delay the development of insecticide resistance in *S. dorsalis*.

1. Introduction

Since its establishment in greater Caribbean during the past decade, *Scirtothrips dorsalis* has been emerging as a significant pest of landscape ornamental plant species and a few economically important food and field crops in parts of the Western Hemisphere. The potential geographic distribution of *S. dorsalis* in the Western Hemisphere probably includes much of Latin America. This invasive species has been encountered in shipments to Europe of produce from India, Kenya, St. Lucia and Thailand (MacLeod and Collins, 2006). The pest causes severe feeding damage to tender meristems and other tissues of more than 112 plant species among 40 different families of plants (CABI/EPPO 1997, CAB, 2003) and it reproduces on most of them (Table 1). Plant species in Florida on which *S. dorsalis* has been found to reproduce are listed in Table 2.

Holtz (2006), using a degree day model (9.7 °C base, 33 °C upper development temperature and 281 degree days from egg to egg), projected that in Florida *S. dorsalis* would have as many as 14–18 generations per year and multiple generations per year in all of the southern and Pacific States of the continental USA. The pest has been predicted to eventually cause >US$ 3.0 billion in annual crop losses in the USA (Holtz, 2006).

S. dorsalis vectors plant damaging viruses including chilli leaf curl virus (CLCV) and peanut necrosis virus (PBNV) (Amin et al., 1981), peanut chlorotic fan virus (PCFV) (Campbell et al., 2005), peanut yellow spot virus (PYSV) (Satyanarayana et al., 1996; Campbell et al., 2005), tobacco streak virus (TSV) (Rao et al., 2003), capsicum chlorosis virus (CaCV), melon yellow spot virus (MYSV)

☆ Trade names or commercial products mentioned in this publication is entirely for research and education purpose and does not involve any endorsement.

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Table 1
Crops in Asia and Africa on which *Scirtothrips dorsalis* appears to be of considerable economic importance.

Host crop	Country; Reference
Cashew, *Anacardium occidentale* L.	India; Ananthakrishnan (1984)
Castor bean, *Ricinus communis* L.	India; Ananthakrishnan (1984)
Chilli pepper, *Capsicum annum* var. *annum* L.	India; Ananthakrishnan (1984)
Citrus, especially *C. unshiu* Marcov (satsuma mandarin)	Japan, Taiwan; Chiu et al. (1991), Chu et al. (2006); Tatara and Furuhashi (1992), Tsuchiya et al., 1995
Cotton, *Gossypium* spp.)	India, Cote d'Ivorie; Bournier (1999)
Grapevine, *Vitis vinifera* L.	India, Japan; Thirumurthi et al. (1972)
Hydrangea spp.	CABI/EPPO (1997)
Kiwi, *Actinidia chinensis* Planchon	CABI/EPPO (1997)
Mango, *Mangifera indica L.*	India; Ananthakrishnan (1984)
Onion, *Allium cepa* L.	India; Ananthakrishnan (1984)
Peanut, *Arachis hypogaea L.*	India; Mound and Palmer 1981).
Pepper, sweet (*Capsicum annum* var. *annum* L.) and hot (*C. chinense* Jacq.)	India, Taiwan, Thailand; CABI/EPPO (1997), Ananthakrishnan (1984)
Persimmon, *Diospyros kaki* Thunb.	Japan; CABI/EPPO (1997)
Rose, *Rosa* spp.	India; Ananthakrishnan (1984)
Rubber tree, *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg.	Taiwan; CABI/EPPO (1997)
Sacred lots, *Nelumbo nucifera* Gaertn.	India; CABI/EPPO (1997)
Soybean, *Glycine max* (L.) Merr.	Indonesia; Miyazaki et al. (1984)
Strawberry, *Fragaria ananassa* X *F. virginiana* Duchesne	Queensland, Australia; Mound and Palmer (1981)
Tamarind, *Tamarindus indica* L.	India; Ananthakrishnan (1984)
Tea, *Camellia sinensis* (L.) Kuntze	Taiwan, Japan; Okada and Kudo (1982)
Tobacco, *Nicotiana tabacum*	India; Ananthakrishnan (1984)
Tomato, *Lycopersicon esculentum* Mill.	India; Ananthakrishnan (1984)
Various ornamentals	India; Ananthakrishnan (1984), Japan

Table 2
Hosts of *Scirtothrips dorsalis* in Florida.

Scientific name	Common or trade name
Antirrhinum majus L.	Liberty Classic White Snapdragon
Arachis hypogaea L	Peanut or groundnut
Begonia sp	Begonia
Breynia nivosa (W. Bull) Small	Snow bush, snow-on-the-mountain
Celosia argentea L.	Celosia – red fox
Coreopsis sp	Tickseed
Cuphea sp	Waxweed, tarweed
Duranta erecta L.	Golden dewdrop, pigeonberry, skyflower
Euphorbia pulcherrima Willd.	Poinsettia
Eustoma grandiflorum (Raf.) Shinn.	Florida Blue Lisianthus
Ficus elastica 'Burgundy' Roxb. ex Hornem.	Burgundy Rubber Tree
Gaura lindheimeri Engelm. & Gray	Lindheimer's beeblossom
Gerbera jamesonii H. Bolus ex Hook. f.	Gerber daisy
Glandularia x hybrida (Grönland & Rümpler) Neson & Pruski	Verbena
Impatiens walleriana Hook. f.	Super Elfin White
Lagerstroemia indica L.	Crape myrtle
Ligustrum sp	Ligustrum
Ocimum basilicum L.	Sweet Basil
Pelargonium × *hortorum* Bailey	Geranium
Pentas lanceolata (Forssk.) Deflers	Graffiti White
Petunia × *hybrida*	Petunia Easy Wave Red
Pittosporum tobira (Thunb.) W.T. Aiton	Variegated Pittosporum
Plectranthus scutellarioides (L.) R. Br.	Coleus
Ricinus communis L.	Castor Bean
Rhaphiolepis umbellate Makino	Yeddo Hawthorn
Richardia brasiliensis Gomes	Brazil Pusley
Rhododendron sp	
Rosa X 'Radrazz'	'Knockout®' rose
Salvia farinacea Benth.	Victoria blue
Schefflera arbicola (Hayata) Merr.	Dwarf umbrella tree
Tagetes patula L.	Marigold
Tradescatia zebrina hort. ex Bosse	Wandering jew
Vaccinium corymbosum L.	Highbush blueberry
Viburnum odoratissimum var. *awabuki* (K. Koch) Zabel	Sweet viburnum
Viburnum suspensum Lindl.	Viburnum
Viola x wittrockiana Gams	Wittrock's violet
Vitis vinifera L.	Grapevine
Zinnia elegans Jacq.	Zinnia Profusion White

Sources: Klassen et al. (2008), Osborne (2009), Seal et al. (2010).

and watermelon silver mottle virus (WsMoV) (Chiemsombat et al., 2008). No report has appeared that indicates that *S. dorsalis* is able to serve as a vector of TSWV. Detection of *S. dorsalis* in fresh vegetation is difficult due to the thigmotactic behavior, small size of the larvae and adults (<2 mm in length) and eggs laid inside host tissue. Therefore, the probability of dissemination of *S. dorsalis* through international trade of fresh horticultural materials is very high.

Previously we reported the effectiveness of various insecticides against *S. dorsalis* (Seal et al., 2006, 2007a,b, 2009). The effective materials identified in these preliminary studies were abamectin, chlorfenapyr, dinotefuran, imidacloprid, novaluron, spinosad, spinetoram, thiamethoxam, borax plus orange oil, *Beauveria bassiana* and *Metarhizium anisopliae* (green muscardine fungus). The materials deemed to be weakly effective in these studies were acetamiprid, azadirachtin, cyfluthrin and other pyrethroids. In a field study on the control of *S. dorsalis* on Sea Island cotton on Barbados, Chu et al. (2006) found that weekly foliar applications at ½ the maximum label rates of chlorfenapyr and spinosad were effective, but that abamectin, acetamiprid, chlorpyrifos, lambda cyhalothrin, deltamethrin, fipronil and thiamethoxam were ineffective. In a landscape study, the organophosphate, acephate (Orthene®), was also found to be effective in controlling *S. dorsalis* (Ludwig and Bogran, 2007). Ciomperlik (2008) reported that the following materials had proven ineffective to control *S. dorsalis* on grapevine in Venezuela: fipronil, omethoate, monocrotophos, a mixture of deltamethrin and triazophos and dimethoate; whereas the following were effective: chlorfenapyr, mixture of abamectin and λ-cyhalothrin and spinosad.

Our perceived need to use different insecticide chemistries in rotation induced us to undertake a more systematic study. In India, *S. dorsalis* populations have arisen with resistance to a range of organochlorine (DDT, BHC and endosulfan), organophosphate (acephate, dimethoate, phosalone, methyl-o-demeton and triazophos) and carbamate insecticide (carbaryl) (Reddy et al., 1992). Thus, it is important to use newer classes of insecticides in accordance with strategies designed to minimize the progressive assembly of genes for resistance through selection.